UNITED STATES DEPARTMENT OF AGRICULTURE
Production and Marketing Administration
Cotton Branch

COTTON TESTING SERVICE

Washington, D. C.
Revised July 1952

CONTENTS

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Introduction

The various cotton fiber and manufacturing tests available on a fee basis under the Cotton Testing Service Act are described herein in order to acquaint cotton breeders, producers, merchants, manufacturers, and others, with the methods employed in making the tests, and with the significance of the test results. A complete list of the tests available and the schedule of fees are shown in a companion publication entitled "Regulations and Fees for Cotton Testing Service," effective January 1, 1952.

Location of Laboratories and the Procedure in Requesting Testing Services

Testing laboratories are operated by the Cotton Branch as follows:

Research and Testing Division, Washington 25, D. C.
Clemson Cotton Laboratory, Clemson, S. C.
Stoneville Cotton Laboratory, Stoneville, Miss.
College Station Cotton Laboratory, College Station, Tex.
Mesilla Park Cotton Laboratory, Mesilla Park, N. Mex.

The special equipment required for many of the tests and the high degree of skill necessary for obtaining accurate results have made it advisable to provide a certain degree of specialization in the making of such tests at the various laboratories. Table 1 shows the kinds of service tests that are being performed at the present time at each of the five laboratories.

The scheduling of tests and the supervision and coordination of the work of all five laboratories are carried out through the Cotton Branch of the Production and Marketing Administration, U. S. Department of Agriculture, Washington, D. C. Therefore, where feasible and for most expeditious service, inquiries concerning tests should be addressed to the Washington office as follows:

Cotton Branch (Research and Testing Division)
Production and Marketing Administration
U. S. Department of Agriculture
Washington 25, D. C.

1/ This publication was planed and prepared under the direction of John W. Wright, Chief, Research and Testing Division, Cotton Branch, Production and Marketing Administration. It is a revision of a similar publication issued in October 1949. This revision reflects the changes brought about by the latest issue of Regulations and Fees for Cotton Testing Service, effective January 1, 1952.

Table 1.--Kinds of service tests performed at each of the five testing laboratories operated by the Cotton Branch, July 1952

Kind of test	Types of laboratory				
	Fiber and spinning		Fiber and ginning		Fiber
	Clemson S.C.	College Station Tex.	Stone-ville Miss.	Mesilla Park N. Mex.	Washington
Cotton Seed:					
Ginning of test samples	No	No	Yes	Yes	No
Foreign matter content	No	No	Yes	Yes	No
Moisture content	Yes	Yes	Yes	Yes	Yes
Fiber tests:					
Length (array)	Yes	Yes	No	No	Yes
Length (Fibrograph)	Yes	Yes	Yes	Yes	Yes
Strength	Yes	Yes	Yes	Yes	Yes
Fineness and Maturity (array)	Yes	Yes	No	No	Yes
Fineness (micronaire)	Yes	Yes	Yes	Yes	Yes
Maturity (random sample)	Yes	Yes	Yes	Yes	Yes
Cross section	No	No	No	No	Yes
Furnishing check samples	No	No	No	No	Yes
Blending test samples	Yes	Yes	Yes	Yes	Yes
Moisture content	Yes	Yes	Yes	Yes	Yes
Foreign matter content	Yes	Yes	Yes	Yes	Yes
Classification	No	No	No	No	Yes
Processing tests:					
Spinning, carded yarns 1/	Yes	Yes	No	No	No
Spinning, combed yarns 1/	Yes	No	No	No	No
Slashing and weaving 2/	Yes	No	No	No	No
Other tests:					
Furnishing identified samples	Yes	Yes	Yes	Yes	Yes
Furnishing copies of results	Yes	Yes	Yes	Yes	Yes

1/ Includes all extra items performed in connection with the spinning tests and other items which are a part of the spinning tests.

2/ Includes spinning of the yarn and testing of the fabric in connection with spinning tests.

The Washington office will notify the person requesting service tests to which laboratory his samples should be sent. If desired, however, requests may be made directly to the laboratory nearest the applicant and test samples may be sent to such laboratory. Samples for tests to be performed at other laboratories will be prepared and forwarded by the laboratory receiving the samples. All seed cotton samples from pink boll worm areas that require ginning prior to testing should be forwarded to the Mesilla Park laboratory, Mesilla Park, N. Mex.

All inquiries concerning policies or the broad interpretation of test results should be addressed to the Washington office. Questions concerning specific test results may be addressed to the laboratory which prepared the report on such tests.

Selection and Preparation of Samples

Results of the fiber and processing tests can be no more representative of cottons than are the samples themselves; therefore, the proper size, selection, and preparation of samples are extremely important. The following suggestions relative to the selection and preparation of samples are designed to aid applicants for testing services in obtaining the most reliable results possible:

Size.--5 ounces or more for fiber tests.
5 pounds or more for each carded yarn spinning test.
8 pounds or more for each combed yarn spinning test.
(When a spinning test on a composite sample representing a mill mix is requested, approximately equal portions from each bale totaling 10 pounds of cotton should be submitted for each mix. When a mill mix contains 40 or more bales, however, at least 4 ounces should be submitted from each bale.)

Selection.--In view of the high degree of variability found for all measurable properties of cotton within a bale, or even within a small sample, it is very important that care be exercised in selecting the fibers that are actually to be tested. Otherwise, the test specimens may not be truly representative, and an erroneous impression may be formed, of the cotton being tested. A more detailed discussion of the problem of variability of cotton appears on page 37.

When breeders submit samples of seed cotton to be ginned, the samples should be representative of the breeding block. In instances where the breeder does his own ginning, the seed cotton should be mixed thoroughly before ginning, and preferably the sample should be drawn from approximately the midpoint in the ginning process. Saw-ginned lint for upland cottons is preferred, as it is not possible to obtain an accurate grade designation for such cotton on roller-ginned samples. Except for comparative purposes, it is inadvisable to submit samples that have been weather damaged, as the lint may no longer be representative of the normal qualities of the seed stock being studied.

Where spinning tests are to be made from commercial bales and other relatively large supplies of lint, the samples should be composed of equal quantities of cotton taken from a number of places in the bale. In cases where a spinning test sample is to represent a mill "mix" equal quantities of cotton should be selected from each bale in the mix, unless otherwise desired by the applicant.

Selection of Tests

In making requests for tests, it should be borne in mind that each test is designed to give specific information regarding some phase or phases of cotton quality. Only those tests that will furnish helpful data in explaining the cotton quality problems being studied should be requested. A well-planned test will generally yield more useful data on a specific problem, and may cost less, than a carelessly planned test. Selection of the tests desired is, of course, a matter for the applicant to decide. Helpful suggestions regarding the most suitable tests for solving specific problems may be obtained, however, by writing to the Washington office or to one of the field laboratories. Requests for such suggestions should outline briefly the purposes for which the service tests are needed and should give any available information regarding the varieties of cotton, place of growth, or other pertinent information. By reviewing Department of Agriculture publications which show the spinning and fiber properties of various varieties and growths of cotton, the applicant may obtain suggestions that will be helpful in determining the kind of tests that are best suited to his purpose.

Description of Tests and Interpretation of Test Results

The bench marks for evaluating fiber and spinning test results that have appeared in previous issues of this publication, as well as in reports of the Cotton Branch pertaining to fiber and spinning test results, were based on annual variety tests made by agricultural experiment stations over a period of years. A recent study of these bench marks in relation to current commercial production of cotton in the United States has indicated the need for some modifications in order to make them more representative of current cotton crops. The bench marks for evaluating the results of tests of various fiber properties, factors of processing performance and yarn quality, as listed herein in connection with the discussion of the various tests, are based on results of extensive tests on the commercial cotton crops of the United States during the crop years 1946-47 to 1951-52, inclusive. For fiber tests, in particular, these benck marks differ in some instances from those previously published. They will now be used as a basis for interpreting all results of fiber and spinning tests made in the laboratories of the Cotton Branch.

Seed Cotton

Ginning of test samples (1). 2/--This test includes the ginning of seed cotton to produce sufficient lint for the fiber and spinning tests. From 5 to 10 pounds of lint are required for these tests. The ginning is performed on a saw gin equipped with an extractor cleaner feeder. When the fiber tests only are requested, 2 pounds of seed cotton may be ginned on a smaller gin without an extractor cleaner feeder. The lint and seed are both weighed and reported along with the percentage of lint turn-out. When spinning tests are to be made on the lint, the ginning laboratory selects, packs, marks, and ships the test samples to the designated spinning laboratory. If the applicant requests it, the cottonseed will be returned at his expense.

Fractionation of foreign material (4).--This test provides a means for determining foreign matter content in samples of seed cotton. Care should be exercised to submit a representative sample of seed cotton weighing from 1 to 2 pounds. The sample is given a preliminary preparation by hand to the extent that sticks and hulls are removed before placing the sample in a device developed by the laboratories of the Cotton Branch for making this test. Compressed air is used to agitate the sample in a semi-cylinderical chamber, and trash is screened from the discharged air. Reports of the test show the average percentage of foreign matter in the seed cotton based on a 300-gram sample.

Fiber Tests and Their Evaluation

A general view of fiber laboratory facilities is shown in figure 1. Fiber tests are conducted under standard atmospheric conditions of 70° F. and 65 percent relative humidity, after the samples have been conditioned for 4 hours or more.

Fiber length array (2).--The test is made with the Suter-Webb fiber sorter (fig. 2). Briefly, three representative 75-milligram samples of cotton are parallelized through a series of combs. The fibers are separated and arrayed on velvet-covered boards according to lengths, as illustrated in figure 3. The different length groups, at 1/8-inch intervals, are measured and weighed. Averages of the results for the three arrays are calculated and reported for the upper quartile length, mean length, and coefficient of length variation.

2/ Numbers in parentheses refer to item numbers in the Regulations and Fees for Cotton Testing Service, effective January 1, 1952.

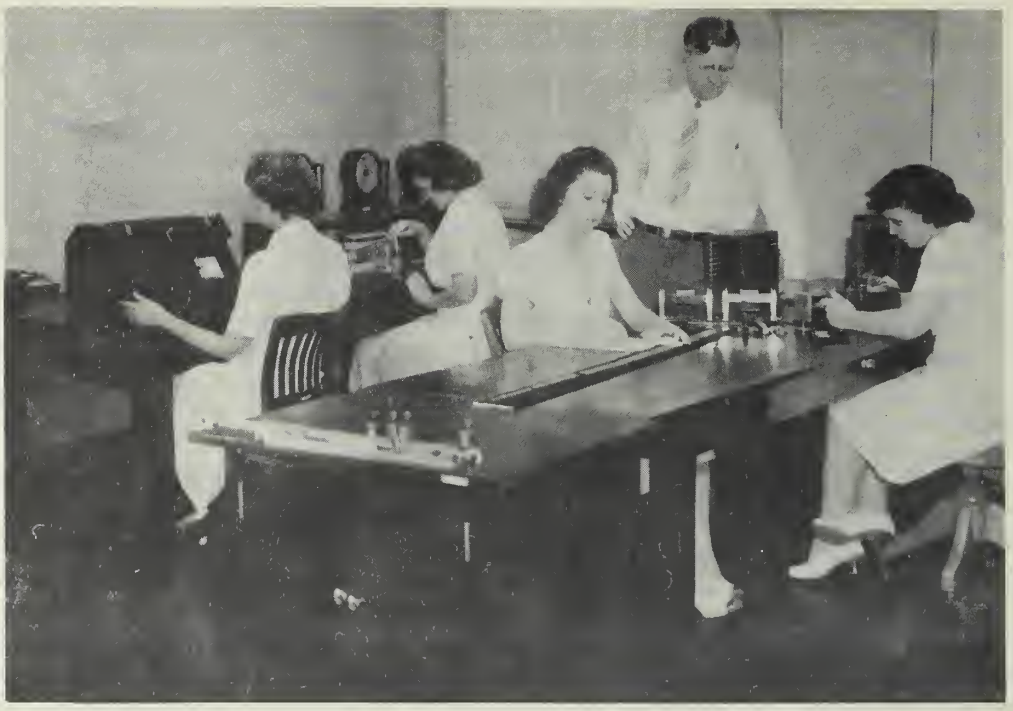


Figure 1. -- General view of fiber laboratory showing technicians making tests to determine various cotton fiber properties.

The upper quartile length is the length which is exceeded by 25 percent of the fibers, by weight, in the sample. It is usually closely related to but slightly longer than the classer's staple length designation. Its relationship to that value may vary, however, because this method does not select and measure "a typical portion of fibers" as required in designating staple length nor does it adjust for character defects for which the classer may reduce the staple length designation.

The mean length is the average length of all fibers in the sample, as determined from the weight-length data.

The coefficient of length variation is a measure of the variability of fiber length in the sample and represents the standard deviation of the weight-length frequencies expressed as a percentage of the mean length. The smaller the value the more uniform are the fiber lengths. Excessive variation in fiber length tends to increase manufacturing waste, makes processing more difficult, and tends to lower the quality of the product. It is, therefore, considered desirable for a cotton to have a low coefficient of variation.

Figure 2.--Illustrating the operation of apparatus for making fiber length analyses: (Top) Suter-Webb fiber sorter and auxiliary equipment; (Bottom) Fibrograph showing an extra set of combs on the left that are ready to be inserted into the machine.

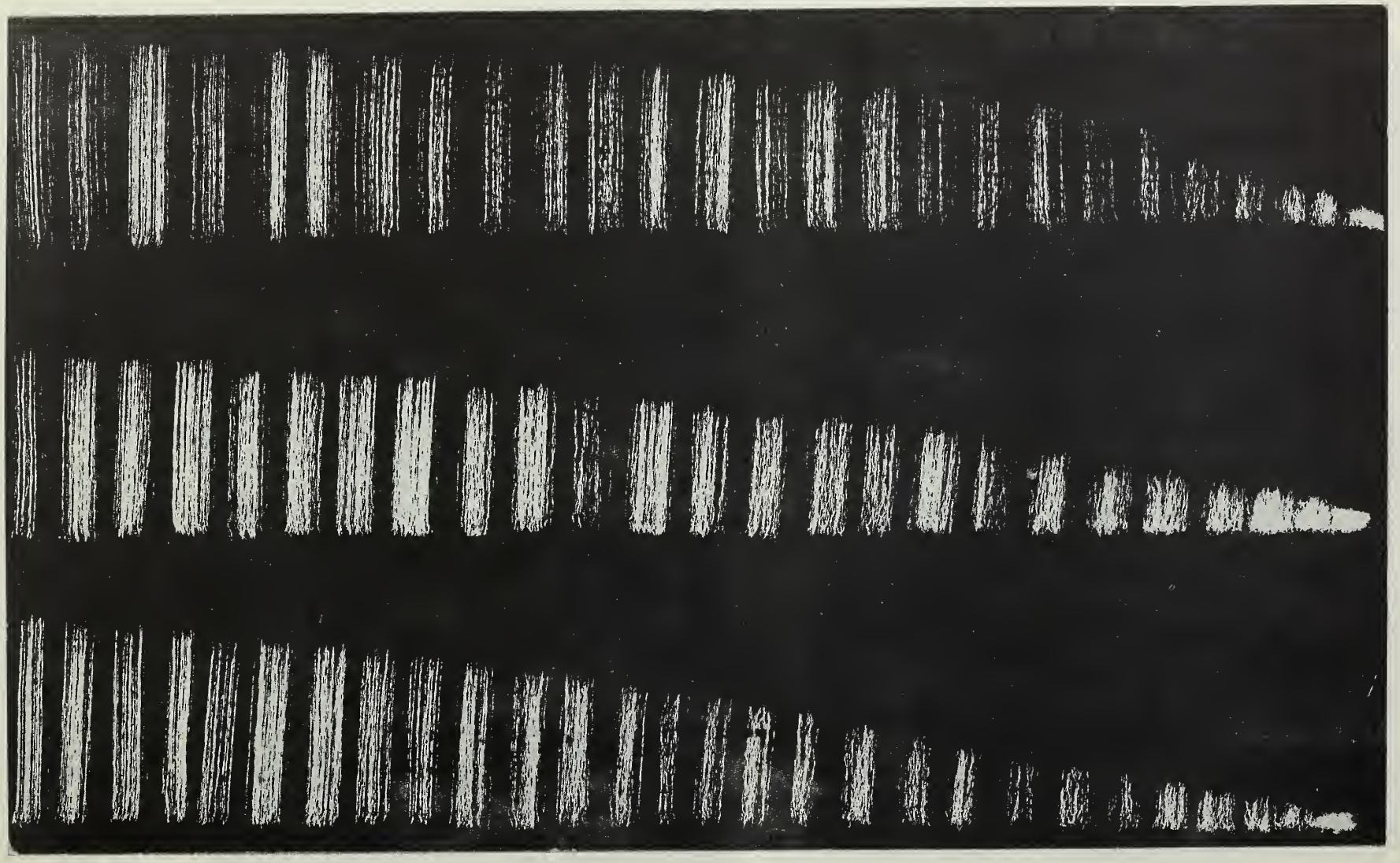


Figure 3.--Fiber length arrays (about actual size) of different cottons illustrating: (Top) A cotton with relatively high length uniformity; (center) average fiber uniformity; (bottom) a cotton of irregular fiber length.

Comparisons between samples may be made according to the following descriptive designations:

Coefficent of fiber length variation

Below 27	Low variability
27 to 34	Average variability
35 and above	High variability

For those persons who desire more complete data for the purpose of plotting fiber length array curves or for more detailed study of length distribution, test (2a) was devised. In addition to the three values reported in test (2),the test (2a) includes the percentage of fibers by weight in each 1/8-inch length group.

Test (2b) was designed to provide detailed data required in connection with the United States Pharmacopoeia standards for purified or absorbent cotton. This test involves the preparation of fiber length arrays on the Suter-Webb sorter, and the determination of the percentages of fiber which are: (a) 1/2-inch long and longer; and (b) shorter than 1/4-inch in length, in keeping with procedures specified in the Second Supplement to the Pharmacopoeia of the United States of America.

Test (2c) is available for determining the upper quartile length, mean length, and coefficient of length variation on samples of manufacturing waste. The significance of these values and other details regarding this test are described under test (2), fiber length array.

Test (2d) is made on samples of manufacturing wastes and the values reported show the upper quartile length, mean length, and coefficient of length variation. In this test the percentage by weight of the fiber in each 1/8-inch group is furnished the applicant in addition to the data reported under test (2c).

All averages reported for fiber sorter results are based on three arrays which have been shown by statistical studies to be necessary for reliable results. A special study indicates that the accuracy of reproducibility of the results for the array test is as follows:

Item	Standard error for cotton: Shorter than 1-1/8" staple	Standard error for cotton: 1-1/8" and longer
Upper quartile length (inches)	± 0.007	± 0.012
Mean length (inches)	± 0.007	± 0.012
Coefficient of length variability (percent)	± 0.7	± 1.2

Fiber length (Fibrograph) (3 and 3a).--These tests provide measures of fiber length as determined by the Fibrograph which is a photoelectric device for measuring the length and length distribution of the fibers in a sample of cotton (fig. 2).

The "upper half mean length," as determined by this instrument, provides a measure of the average length of all fibers longer than the mean length, expressed in terms of decimal fractions of an inch. Although the "upper half mean length" is closely related to the classer's designation of staple length, it may vary from that value because this method does not select and measure "a typical portion of fibers" as required in designating staple length nor does it adjust for character defects for which the classer may assign a shorter staple length designation. "Mean length" is the average length of the fibers in the sample, excluding those approximately 1/4 inch and shorter. The "uniformity ratio" expresses the relation between the mean length of the fibers and the upper half mean length, and provides a relative measure of the length uniformity of the fibers. The larger the value reported, the more uniform the fiber length. For practical purposes, comparisons between samples may be made according to the following descriptive designations:

Uniformity ratio

Above 80	Uniform in fiber length
75 to 80	Average uniformity
74 and below	Irregular in fiber length

The uniformity ratio as determined from Fibrograph data is not mathematically comparable with coefficient of variation based on the sorter array. The latter is based on the weight of all fibers in the sample, whereas the Fibrograph data are based on the number of fibers and disregards fibers approximately 1/4 inch and shorter.

Average Fibrograph values reported for individual samples, item (3), are based on four determinations which have been shown by statistical studies to be necessary for reliable results. In the case of item (3a), however, the results for the two determinations on each of three or more subsamples are averaged to obtain a representative value for the entire group of replicate subsamples. A special study indicates that the accuracy of the reproducibility of the results for the Fibrograph test as based on four determinations is as follows:

Item	Standard error for cottons shorter than 1-1/8" staple
Upper half mean length (inches)	± 0.008
Mean length (inches)	± 0.015
Length uniformity (index)	± 1.1

Fiber strength (5 and 5a).--Fiber tensile strength is determined by using a flat bundle Pressley strength tester (fig. 4). In making the test, cotton is hand-combed and the fibers are parallelized in the form of a flat

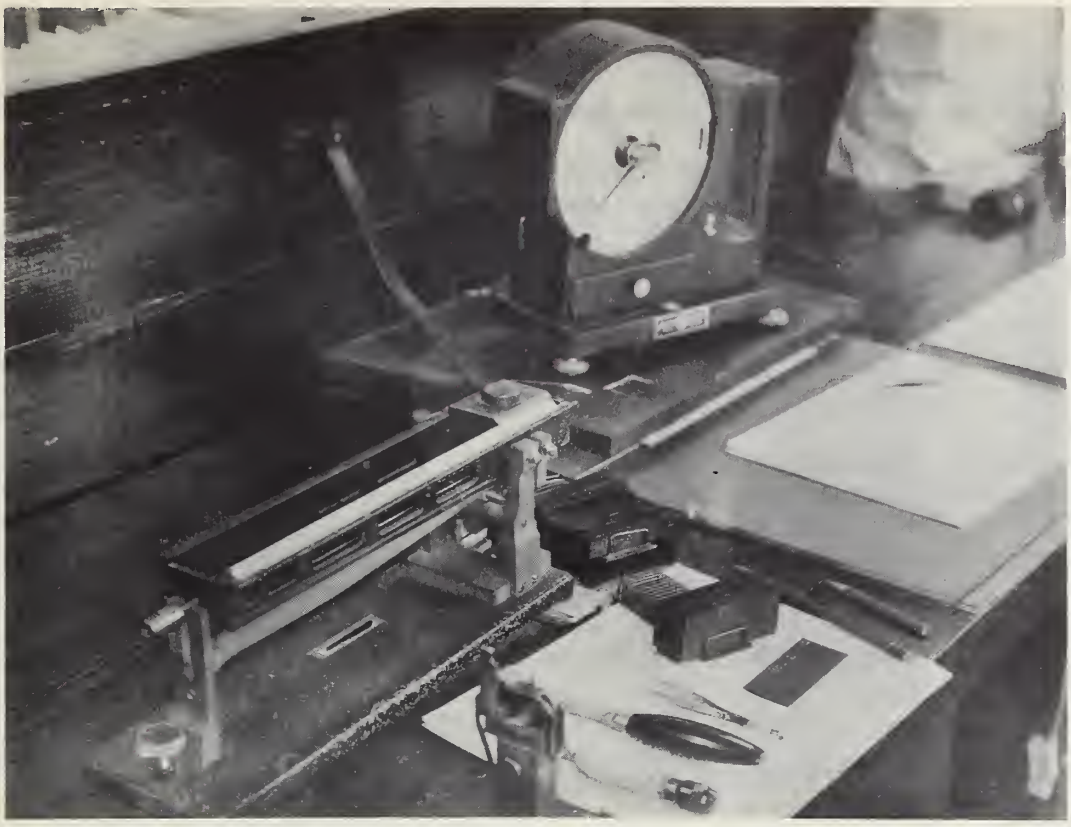


Figure 4.--Pressley strength tester (left foreground), torsion balance, and other auxiliary equipment used in determining the tensile strength of cotton fibers.

ribbon about 1/4-inch wide and then placed in a set of breaking clamps. The fibers are cut to a definite length, broken in the Pressley tester, and then weighed. The strength of the specimen, as indicated on the beam of the machine, is read to the nearest tenth of a pound and the weight of the specimen is read to the nearest hundreth of a milligram. The breaking strength in thousand pounds per square inch is calculated by using the following formula:

$$\text{Tensile strength (1,000 lb./sq.in.)} = \frac{10.8116 \times \text{Beam reading}}{\text{Specimen weight}} - 0.12$$

If the Pressley index is desired it may be obtained by using the following formula:

$$\text{Pressley index} = \frac{\text{1,000 lb./sq.in.} + 0.12}{10.8116}$$

Fiber strength is an important factor in determining yarn strength. Cottons with good fiber strength usually give less trouble in manufacturing processes than do weak-fibered cottons.

The following designation will assist in the interpretation of the test data reported and serve to facilitate comparisons between cottons:

Fiber strength
(1,000 pounds per square inch)

Above 95	Very strong
86 to 95	Strong
76 to 85	Average
66 to 75	Weak
65 or less	Very weak

The average strength reported for individual samples, item (5), is based on six breaks which have been shown by statistical studies to be necessary for reliable results. In the case of item (5a), however, the results for the two breaks on each of three or more subsamples are averaged to obtain a representative value for the entire group of replicate subsamples. A special study indicated that the accuracy of the reproducibility of the results for the Pressley strength test, as based on six breaks, is as follows:

	Standard error
Fiber strength (1,000 lb./sq.in.)	± 0.9

Fiber fineness (weight per inch) and maturity (6).--In making these tests by the array method, two fiber-length arrays are first made. For the fineness test, approximately 100 fibers are extracted from each 1/8-inch length array group and are weighed. The average weight per inch of fiber in the sample is then calculated and expressed in terms of micrograms per inch of fiber. The larger the value reported the coarser the fibers, and, conversely, the lower the value the finer the fibers. As a general rule, long cottons are finer fibered than short cottons (fig. 5). Fiber fineness contributes to yarn strength and the importance of this fiber property to yarn strength increases as finer counts of yarn are spun. Very fine fibers, however, tend to increase neppiness and to reduce the rate of processing, so that the desirability of fiber fineness depends on the specific end product or use. For American upland cottons, the following adjective ratings may be applied for purposes of comparisons:

Fiber fineness
(Micrograms per inch of fiber)

Below 3.0	Very fine
3.0 to 3.9	Fine
4.0 to 4.9	Average
5.0 to 5.9	Coarse
6.0 and above	Very coarse

Figure 5.--Reproduction of raw cotton fibers showing gradations in fineness found in American upland cotton (about 230X).

A false impression of inherent fineness is frequently imparted by highly immature cottons, and for this reason a measure of maturity is almost a necessity in evaluating cottons on the basis of their fiber weight. Fiber maturity is determined by examining approximately 100 fibers from each 1/8-inch group of the array, under high-power magnification, to determine the thickness of the fiber cell walls in relation to the lumen after the fiber walls are swollen by applying an 18-percent solution of sodium hydroxide. This swelling of the fiber walls accentuates differences in wall thickness and facilitates the determination of the proportions of thick-walled fibers and thin-walled fibers, which indicate maturity and immaturity, respectively. Although thickness of cell wall is to some extent a varietal characteristic, this property varies significantly with growth conditions. Statistical analyses have shown that fiber maturity is a desirable characteristic from the standpoint of low picker and card waste since it ranks second only to grade in this respect. For fine combed yarns, the more mature cottons produce yarns having significantly better appearance grades than those of less mature cottons. Cotton differing in degree of maturity do not dye uniformly. Immature fibers are a source of neps which are also an important factor affecting the appearance of finished fabrics.

The following descriptive terms may be applied to classify cottons with respect to maturity:

Fiber maturity (percent)	
Above 85	Mature
76 to 85	Average
66 to 75	Immature
65 and below	Very immature

Test (6a), which is a combination of fiber length (2) and fineness and maturity (6), is offered at a reduced fee because this combination can be made in less time than that required for the aggregate of the individual tests. Since item (6) involves the making of arrays as a basis for the fineness and maturity tests, item (2) can be included with a relatively small amount of additional work.

Test (6b and 6c), fiber fineness by the Micronaire, is a more rapid method for determining fiber fineness than the array method described above. The Micronaire instrument (fig. 6) used in this method was designed to evaluate fineness of cotton fiber by measuring the resistance to the passage of air through a 50-grain sample compressed to a given volume. A linear scale for this instrument was initially adopted to indicate a direct reading in micrograms per inch. Further studies, however, indicated a curvilinear relationship between micronaire readings and actual array weight per inch determinations on American upland cottons. As a result of the studies, a curvilinear micronaire scale for upland cotton was adopted in September 1950. Studies of the adaptability of the micronaire for measuring of American Egyptian and other extra long staple cottons indicated that neither the original linear scale nor the revised scale for upland cottons gave satisfactory results in relation to actual weight per inch for such cottons. A separate scale developed specifically for these cottons was, therefore, adopted in January 1952. The two scales now being used on the Micronaire are shown in figure 7. The discussion of the fiber fineness results and the adjective ratings listed above for the array method also apply to fiber fineness by the Micronaire method.

Test (6d and 6e), fiber maturity by the random sample method, is a more rapid method for determining fiber maturity than the array method described above. In this method, six observations of approximately 150 fibers each extracted direct from a blended sample are examined under high-powered magnification by use of a microprojector to determine the thickness of the cell walls in relation to the lumen, after the fiber walls are swollen by applying an 18-percent solution of sodium hydroxide. The discussion of the fiber maturity results and the adjective ratings listed above also apply to fiber maturity by the random sample method.

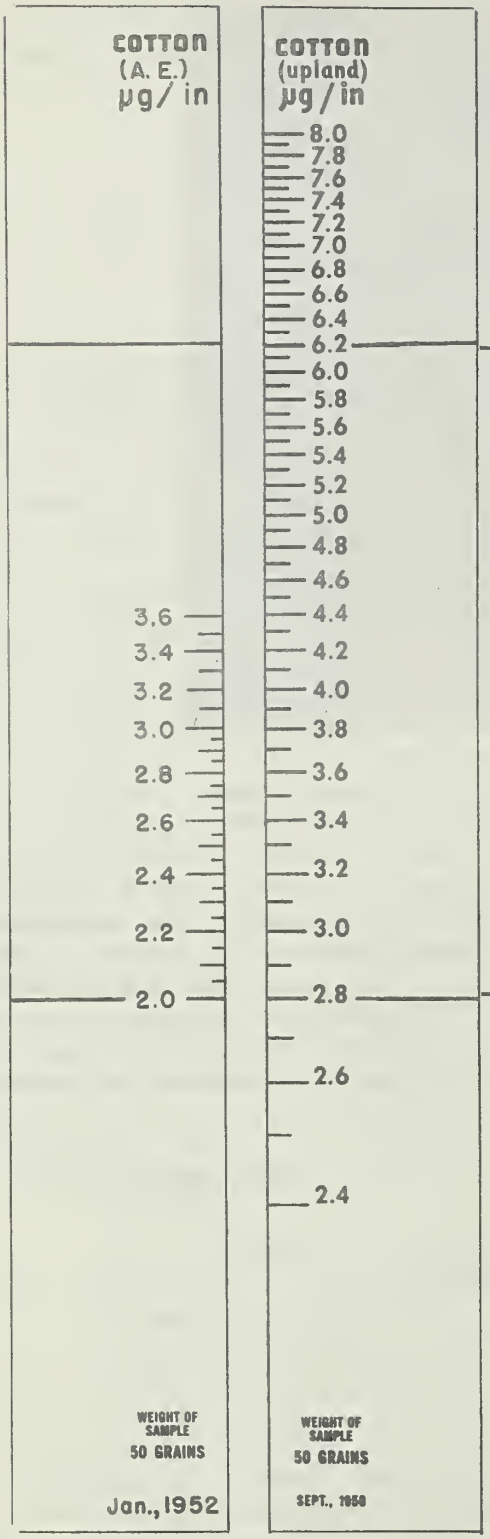
All averages reported for fiber fineness and maturity are based on two determinations on each 1/8-inch length group longer than 3/16-inch for the array method (item 6), on two determinations for fineness by the micronaire

Figure 6.--Inserting a specimen into the specimen holder of the Micronaire cotton-fineness tester.

method (item 6b), and on six determinations for maturity by the random sample method (item 6d). In the case of item (6c), however, one determination on each of two or more subsamples are averaged to obtain a representative value for the entire group of replicate subsamples. The number of determinations used in each instance has been shown by statistical studies to be necessary for reliable results. A special study indicated that the accuracy of the reproducibility of the results for the fineness and maturity tests is as follows:

Item	Standard error
Fiber fineness by Micronaire method (mg/in.)	± 0.05
Fiber maturity by random sample method (percent):	
For 90 percent maturity	± 0.8
For 80 percent maturity	± 1.0
For 70 percent maturity	± 1.2
For 60 percent maturity	± 1.3

Fiber cross-section (7).--In this test a small tuft of fibers is placed in a Hardy-type microtome and a very thin cross section of fibers is cut. A photomicrograph of the fibers magnified 1,000 times is made to provide a cross sectional view of the fibers. Measurements are then made of 200 fibers and, from these measurements, the average fiber "diameter" and wall thickness, in microns, and the circularity ratio are calculated. The



Upper instrument calibration

Equations relating to Micronaire linear scale with the curvilinear scales:

$Y_1 = 1.514 + 0.0413X + 0.101X^2$

$Y_2 = 2.314 + 0.0413X + 0.101X^2$

$Y_1 = Y_2 - 0.8$

Y_1 = American Egyptian fiber-fineness

Y_2 = American upland fiber-fineness

X = Micronaire linear scale (inches)

Lower instrument calibration

Figure 7.--Micronaire fiber-fineness scales for both American upland and American Egyptian cottons.

report shows these values and includes a print of the photomicrograph, which is larger but similar in other respects to those shown in figure 8.

In these calculations, the diameter of a fiber is assumed to be one-half the sum of the long axis and the short axis of the fiber cross section. The circularity ratio is the ratio of the long axis to the short axis of the fiber, and the wall thickness is one-half the difference of the over-all width less the lumen width. These measurements provide measures of the cross sectional characteristics not obtainable in any other way. If a print of the photomicrograph is desired without any measurement or calculation being made, this can be obtained by requesting item 7a. Additional photographic prints of item 7 or 7a can be obtained by requesting test item 7b.

Furnishing check test samples (8).--This test item has been offered to meet the needs of a number of applicants who operate their own laboratories. A 1-pound sample of short, medium, or long staple length American cotton including data showing results obtained in the Cotton Branch laboratories for length array, in accordance with test 2a, length by the Fibrograph, strength by the Pressley method, fineness by the Micronaire method, and maturity by the microprojector method are furnished for laboratory check tests. This affords the applicant an opportunity to correlate the results obtained in his laboratory with those obtained in the Cotton Branch laboratories.

Blending samples for fiber tests (9).--In view of the relatively small quantity of cotton used as specimens with many laboratory test instruments, it is highly important that these specimens be representative of the entire sample. To accomplish this, 32 pinches of cotton are taken at random from different parts of the laboratory sample and these pinches are blended on a mechanical blender (fig. 9). The blender mixes the individual fibers into a practically homogeneous mass and specimens taken from any part of the blended sample are representative. Specimens for the fiber tests described above, except for the subsample tests (items 3a, 5a, and 6c), are taken from a mechanically blended sample. A sample weighing 7 grams provides sufficient cotton for all the usual fiber tests. Item (9) provides a means for the applicant to obtain a 7-gram mechanically blended sample for fiber tests in his own laboratory. If more than 7 grams are desired, additional cotton will be blended in accordance with the fees listed in the Regulations and Fees for Cotton Testing Service.

Determination of moisture content (10).--This test consists of the weighing and drying of 20-gram samples of ginned cotton lint, cotton stock at various stages of processing, cotton yarn, or cotton manufacturing wastes. The samples are dried in drying ovens and the moisture content is calculated by using the following formula:

$$\text{Moisture content percentage} = \frac{\text{Original weight - dry weight} \times 100}{\text{Original weight}}$$

The moisture content percentage is reported for each sample.

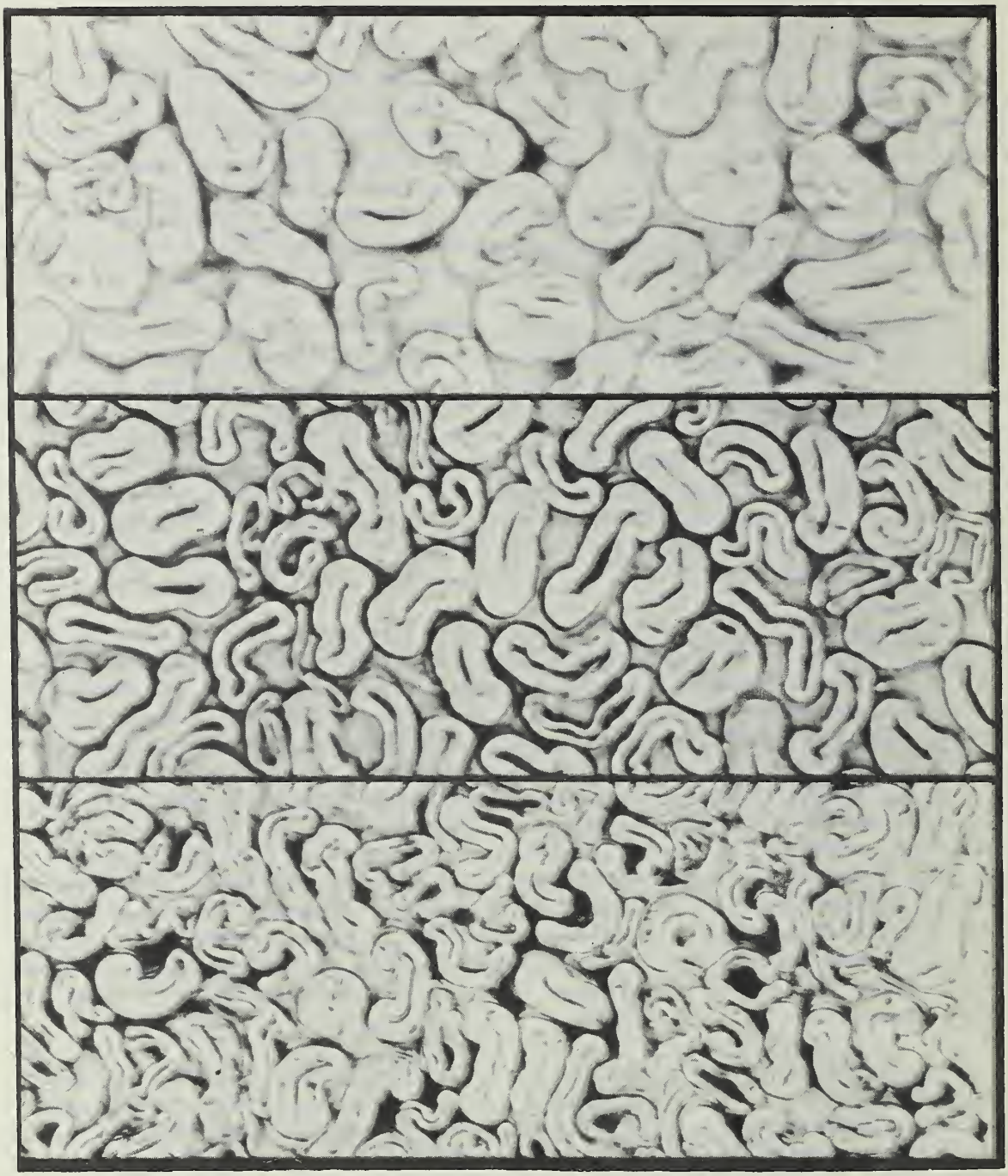


Figure 8.--Photomicrographs of cotton fiber cross-sections showing: (Top) Very mature cotton; (middle) average maturity; (bottom) very immature cotton fibers (about 1,000X).

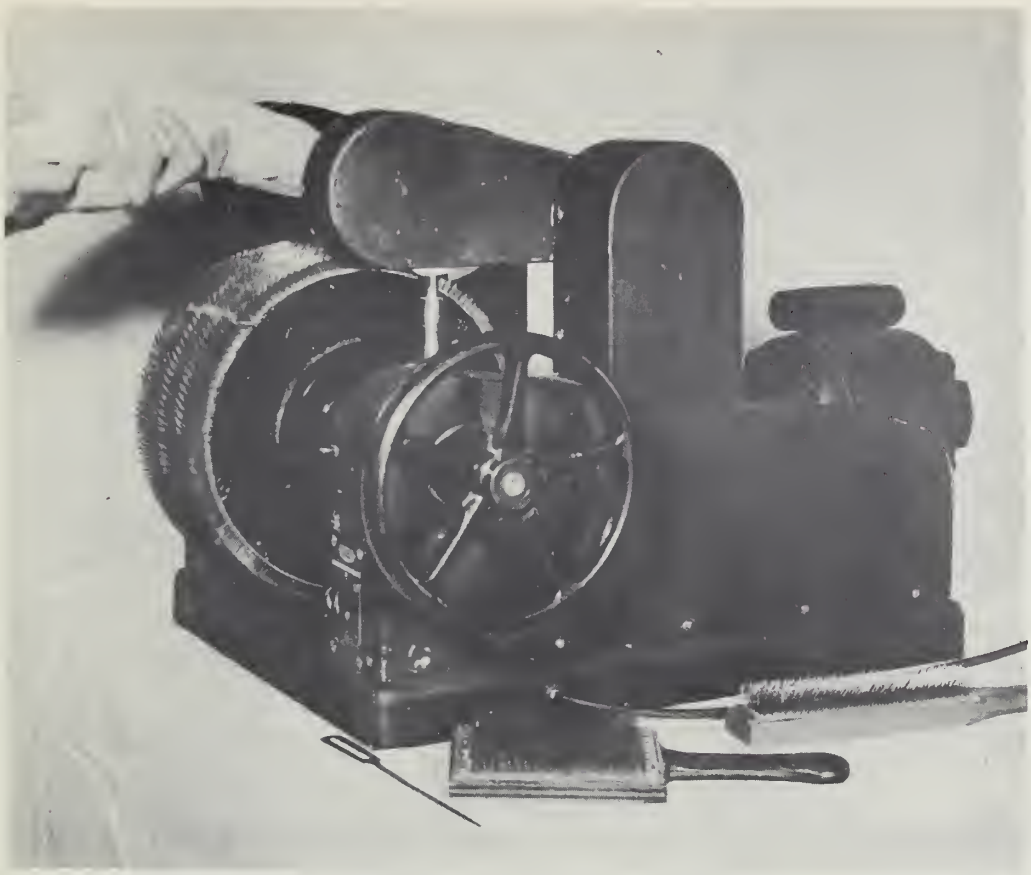


Figure 9.--Feeding a sample of cotton to the mechanical cotton fiber blender.

Shirley Analyzer test (25).--In this test, a sample of ginned cotton lint or cotton waste is weighed and processed through the Shirley anlayzer (fig. 10). This machine make an almost perfect separation of lint and trash. The percentage of nonlint content is reported. Nonlint removed by the Shirley analyzer differs from total picker and card waste (items 11 through 14) in that it contains practically no fiber, whereas, an appreciable quantity of fiber is removed as waste in mill cleaning machines. Since both ginned lint and various types of mill wastes can be analyzed, this test is useful for a number of research purposes. The cleaned lint and/or the trash removed are returned to the applicant requesting the test for his inspection and use when specifically requested in accordance with the provisions of item (26). Fees have been established, as listed in the Regulations and Fees for Cotton Testing Service, under item (25) for the following types of samples:

4-ounce sample (100 grams) of ginned lint.
4-ounce sample (100 grams) of cotton waste.
1-pound sample of ginned lint.
1-pound sample of cotton waste.

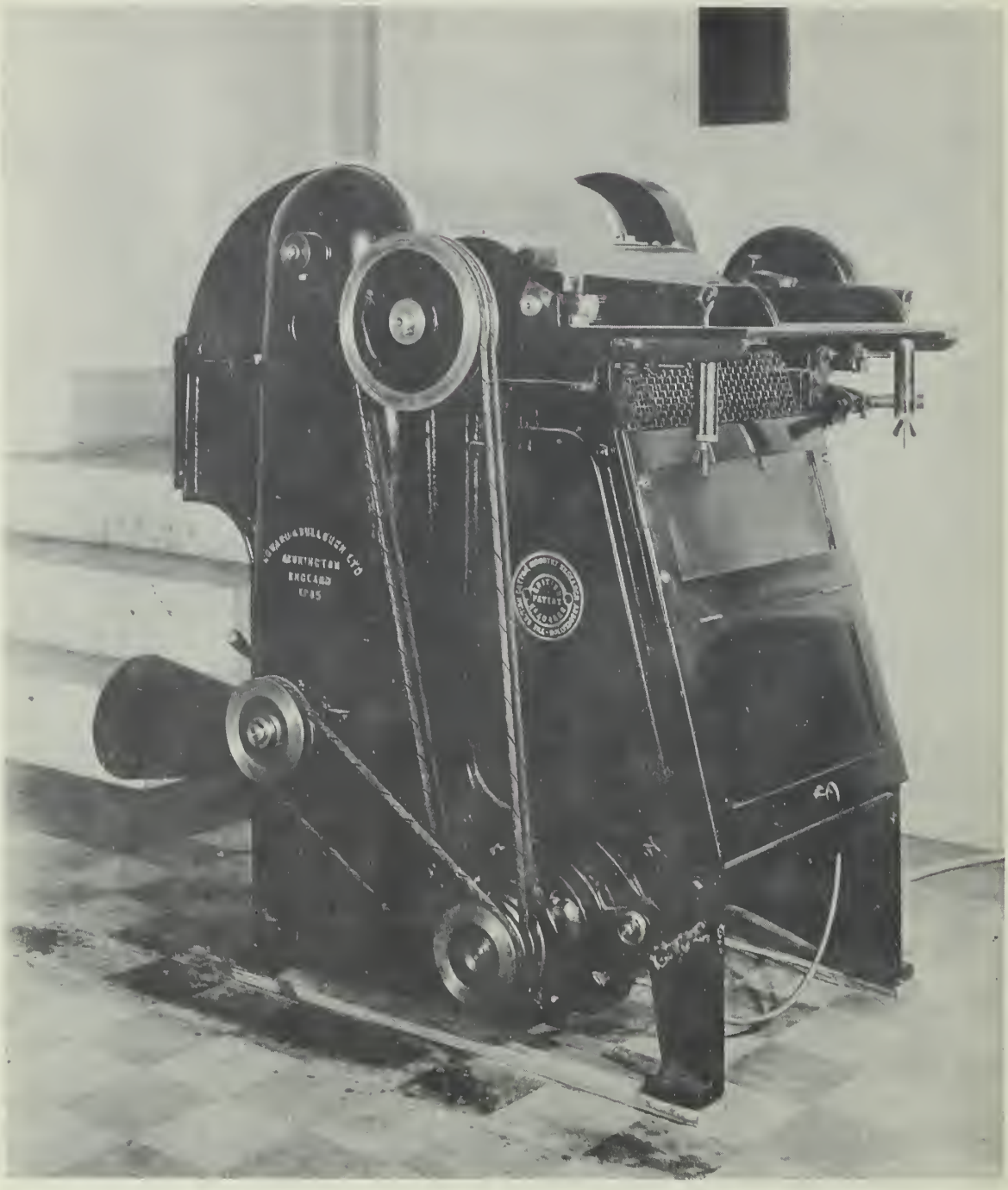


Figure 10.--Shirley analyzer used for separating foreign matter from fibers in samples of raw cotton, manufacturing waste, or purified cotton.

On the basis of tests made on bales used in the white grade standards, the following scale has been established to represent percentages of nonlint removed by the Shirley analyzer from different grades:

Grade	Nonlint content Percent
Strict Good Middling	2.0
Good Middling	2.4
Strict Middling	2.9
Middling	3.7
Strict Low Middling	5.1
Low Middling	7.6
Strict Good Ordinary	11.0
Good Ordinary	17.0

By similar tests, the following scale has been developed to represent the grades for American Egyptian cotton:

Grade of cotton	Nonlint content Percent
1	1.9
1-1/2	2.4
2	3.3
2-1/2	4.7
3	6.5
3-1/2	8.8
4	11.5
4-1/2	14.7
5	18.3

The foregoing tabulations were derived from smoothed curves drawn on the basis of these data. Differences in results obtained for individual samples and percentages shown may be caused by the following: (1) There are intentional allowances for variations in trash content among bales in each standard grade (to offset differences in color and provide a range for the grade) that may amount to an overlap, particularly in the higher grades; and (2) the tabulation figures are based on weight and they do not take into consideration the nature of trash, which is sometimes as important as weight in determining the grade designation.

Nonlint content results obtained in the laboratories of the Cotton Branch for cottons which have been tested over a period of years provide an indication of the reproducibility of results for the Shirley analyzer test, as follows:

Item	Standard error
Nonlint content (percent)	± 0.4

Classification for grade and staple length (28).--The classification is based on the Official Cotton Standards for Grade and Staple Length.

Processing Tests and Their Evaluation

In the final analysis, the actual results obtained in processing different samples of cotton and in the testing of the resulting yarns provide the most satisfactory basis for evaluating the relative merits of the cottons represented by such samples. Laboratory equipment and techniques have now been developed to a point where reliable spinning test results can be obtained from small samples of cotton.

Spinning tests (items 11 through 15) are provided for carded yarns, combed yarns, and combinations of both carded and combed yarns. In commercial practice, most cottons 1-1/8 inches and longer are manufactured into combed yarns. Although a considerable quantity of cotton shorter than 1-1/8 inches is used for combed yarns, the major part of it is used for carded yarns. Applicants for spinning tests should indicate in each instance whether a carded test, a combed test, or a combination of these two tests is desired.

Spinning tests are conducted on commercial-type cotton-processing machinery by the use of standardized laboratory procedures and techniques which have been developed to insure reproducible results (fig. 11). The processing procedure for carded yarn spinning tests include opening by hand, two processes of picking (both of which are performed on a finisher picker), conventional carding, two processes of drawing, one superdraft roving process, and double rovings fed to long-draft spinning frames. In addition to the carded yarn processes, the card sliver for combed yarn spinning tests is passed through a sliver lapper, a ribbon lapper, and a comber. The second process of drawing is omitted. A second process of roving (regular draft) is also added for combed yarns finer than 60s. All spinning test processes are performed under controlled atmospheric conditions for both temperature and humidity.

The range of yarn numbers that can be spun from a cotton is dependent on its staple length and other properties usually associated with length. Also, the quality requirements are generally higher for products made from the finer yarn numbers than they are for products made from coarser yarn numbers. The finer numbers are, therefore, generally spun commercially from the longer staple cottons at relatively low-production rates; whereas, the coarser numbers are generally spun commercially from the shorter staple cottons at relatively high-production rates. In order to more nearly approach commercial practice, four standard organizations have been set up to cover the range of staple length of cottons normally grown in this country. Each of these organizations include two yarn numbers to provide data in terms of a relatively wide range. Table 2 shows yarn numbers, finest yarn number to spin, twist multiplier, carding rate, and comber settings that have been adopted as standard for various fiber lengths.

Figure 11.--General view of the processing equipment used in the card room at one of the cotton spinning laboratories. Shown on the right is a comber; in the left foreground a sliver lapper; and back of this machine a card, drawing frame, and roving frames.

Other details for each of the four organizations are shown in table 3.

The use of the standard organization as based on the fiber length of a particular sample is desirable in order that specific test results may be interpreted on the basis of research and other data accumulated over a period of years. Any two standard laboratory yarn numbers (14s, 22s, 36s, 44s, 50s, and 60s carded or 14s, 22s, 36s, 44s, 50s, 60s, 80s, and 100s combed) that are within the spinnable limits of the particular cotton may, however, be specified by the applicant. The two standard yarn numbers selected are spun with the optimum twist multiplier for the fiber length in all instances. Any one of the standard carding rates (6-1/2, 9-1/2, and 12-1/2 lb./hr. for carded yarns or 3-1/2, 6-1/2, and 9-1/2 lb./hr. for combed yarns) and any one of the standard comber settings (0.42, 0.48, and 0.54 inch to extract an estimated 12, 15, or 18 percent comber waste, respectively) may also be specified by the applicant. Unless the tests are performed according to the standard procedures as based on the fiber length of the particular sample, however, the general interpretation of results as listed in subsequent paragraphs is not applicable.

Table 2.--Yarn numbers, finest yarn number to spin, twist multiplier, carding rate, and comber setting which have been adopted as standard for various fiber lengths

Upper half mean length (Fibrograph)	Standard yarn numbers		Finest standard yarn number 1/	Standard twist multiplier	Standard carding rate	Standard comber setting
	Low	High				
Inches	Number	Number	Number	Number	lb./hr.	Inches
Organization I - Carded yarns only:						
0.62 and below	14s	22s	22sK	5.35	12-1/2	
.63 to .66	14s	22s	22sK	5.15	12-1/2	
.67 to .70	14s	22s	36sK	5.00	12-1/2	
.71 to .74	14s	22s	36sK	4.85	12-1/2	
.75 to .78	14s	22s	36sK	4.70	12-1/2	
.79 to .82	14s	22s	36sK	4.60	12-1/2	
.83 to .86	14s	22s	44sK	4.45	12-1/2	
.87 to .89	14s	22s	44sK	4.35	12-1/2	
.90 to .93	14s	22s	44sK	4.25	12-1/2	
.94 to .97	14s	22s	44sK	4.20	12-1/2	
Organization II - Carded yarns (also combed yarns when specified):						
0.98 to 1.01	22s	50s	50sK-60sC	4.10	9-1/2	0.42
1.02 to 1.05	22s	50s	50sK-60sC	4.05	9-1/2	.42
1.06 to 1.09	22s	50s	50sK-60sC	3.95	9-1/2	.42
1.10 to 1.13	22s	50s	50sK-60sC	3.90	9-1/2	.42
Organization III - Carded and combed yarns:						
1.14 to 1.16	22s	50s	60sK-80sC	3.85	6-1/2	0.48
1.17 to 1.20	22s	50s	60sK-80sC	3.80	6-1/2	.48
1.21 to 1.24	22s	50s	60sK-80sC	3.75	6-1/2	.48
1.25 to 1.28	22s	50s	60sK-80sC	3.70	6-1/2	.48
Organization IV - Combed yarns only:						
1.29 to 1.32	50s	80s	100sC	3.65	3-1/2	0.54
1.33 to 1.36	50s	80s	100sC	3.60	3-1/2	.54
1.37 or more	50s	80s	100sC	(as required	3-1/2	.54

1/ K represents carded yarns and C represents combed yarns. When a yarn number requested is found to be too fine to spin from a particular cotton because of excessive spinning end breakage, the results for such yarns will be reported as "too fine to spin from this cotton." If this number is not finer than the finest spinnable number as listed in the table, however, a coarser number that is within the spinnable limits of the cotton will be substituted.

Table 3.--Spinning test procedures for specified standard organizations

Process	Specified Organization 1/			
	I	II	III	IV
1. PICKER				
Each test lot is processed through a finisher type picker twice to produce the specified weight of lap (ounces per yd.)	11	11	11	11
Type of beater	Kirschner	Kirschner	Kirschner	2-blade
Beater speed (r.p.m.)	1,000	1,000	1,000	1,000
Settings:				
Feed roll to beater (inches)	3/16	3/16	3/16	3/8
Grids to beater, top (inches)	5/16	5/16	5/16	9/16
Grids to beater, bottom (inches)	11/16	11/16	11/16	9/16
2. CARD				
Feed, picker lap (oz. per yd.)	11	11	11	11
Delivered one sliver (grains per yd.)	40	40	40	40
Production rate (pounds per hour)	12-1/2	9-1/2	6-1/2	3-1/2
Doffer speed (r.p.m.)	14	10	7	4
Cylinder speed (r.p.m.)	165	165	165	165
Speed of flats (inches per minute)	2-7/8	2-7/8	2-7/8	2-7/8
Licker-in speed (r.p.m.)	435	435	435	435
Settings:				
Feed plate to licker-in (inches)	0.010	0.010	0.010	0.017
Mote knife to licker-in, top (inches)	.012	.012	.012	.012
Mote knife to licker-in, bottom (inches)	.010	.010	.010	.010
Licker-in screen, front (inches)	.029	.029	.029	.029
Licker-in screen, back (inches)	.017	.017	.017	.017
Licker-in to cylinder (inches)	.007	.007	.007	.007
Flats to cylinder, back, center, and front (inches)	.009	.009	.009	.009
Back plate to cylinder, top (inches)	.029	.029	.029	.029
Back plate to cylinder, bottom (inches)	.034	.034	.034	.034
Front plate to cylinder, top (inches)	.029	.029	.029	.029
Front plate to cylinder, bottom (inches)	.034	.034	.034	.034
Doffer to cylinder (inches)	.007	.007	.007	.007
Cylinder screen, back (inches)	.029	.029	.029	.029
Cylinder screen, center (inches)	.034	.034	.034	.034
Cylinder screen, front (inches)	3/16	3/16	3/16	3/16
Doffer comb to doffer (inches)	.022	.022	.022	.022
3. SLIVER LAPPER (combed only)				
Fed, 20 slivers (wt. per yd. each, grains)	---	40	40	40
Delivered 1 lap (grains per yd.)	---	525	525	525
Speed (yds. per minute)	---	46	46	46
Roll settings (center to center):				
First to second (inches plus fiber length) 2/	---	5/16	5/16	5/16
Second to third (inches plus fiber length) 2/	---	9/16	9/16	9/16
4. RIBBON LAPPER (Combed only)				
Fed, four sliver laps (grains per yd, each)	---	525	525	525
Delivered one lap (grains per yd.)	---	610	610	610
Speed (yards per minute)	---	47	47	47
Roll settings (center to center):				
First to second (inches plus fiber length) 2/	---	4/16	4/16	4/16
Second to third (inches plus fiber length) 2/	---	7/16	7/16	7/16
Third to fourth (inches plus fiber length) 2/	---	10/16	10/16	10/16
5. COMBER (Model D-4)				
Fed, eight ribbon laps (grains per yd., each)	---	610	610	610
Delivered, one sliver (grains per yd.)	---	40	40	40
Production per hour (pounds)	---	13	13	13
Cushion plate to detaching roll setting(inches)	---	.42	.48	.54
Estimated or nominal waste (percent)	---	12	15	18

See footnotes at end of table.

Table 3.--Spinning test procedures for specified standard organizations (Continued)

Process	Specified Organization 1/			
	I	II	III	IV
6. DRAWING FRAME (leather top rolls)				
Carded stocks, first process:				
Fed, 6 card slivers (grains per yd. each)	40	40	40	---
Delivered one sliver (grains per yd.)	42	42	42	---
Carded stocks, second process:				
Fed, 6 slivers (grains per yd. each)	42	42	42	---
Delivered one sliver (grains per yd.)	44	44	44	---
Combed stocks (one process only):				
Fed, 6 comber slivers (grains per yd. each)	---	40	40	40
Delivered, one sliver (grains per yd.)	---	44	44	44
Speed (yards per minute)	36	36	36	36
Roll settings (center to center):				
First to second (inches plus fiber length) 2/	4/16	4/16	4/16	4/16
Second to third (inches plus fiber length) 2/	7/16	7/16	7/16	7/16
Third to fourth (inches plus fiber length) 2/	10/16	10/16	10/16	10/16
7. LONG DRAFT ROVING (8 x 4, 2 apron type)				
Fed, one sliver (grains per yd.)	44	44	44	44
Delivered, 2.50 through 4.50 hanks 3/				
Spindle speed (r.p.m.)	1250	1250	1250	1250
Roll settings (center to center):				
First to second, standard (inches)	2-1/4	2-1/4	2-1/4	2-1/4
Third to fourth (inches plus fiber length) 2/	1/4	1/4	1/4	1/4
8. REGULAR DRAFT ROVING (6 x 3, for 80s and 100s combed yarns):				
Fed double (hanks each)	---	---	---	3.25
Delivered (hanks)	---	---	---	8.50
Spindle speed (r.p.m.)	---	---	---	1200
Roll settings (center to center):				
First to second (inches plus fiber length) 2/	---	---	---	2/16
Second to third (inches plus fiber length) 2/	---	---	---	4/16
9. LONG DRAFT SPINNING (two apron type)				
Fed double for 14s (hanks each)	2.50	---	---	---
Fed double for 22s & 36s (hanks each)	3.25	3.25	3.25	---
Fed double for 40s, 50s, & 60s (hanks each)	---	4.50	4.50	4.50
Fed double for 80s & 100s (hanks each)	---	---	---	8.50
Spindle speeds for 14s & 36s (r.p.m.)	9,000	---	---	---
Spindle speeds for 22s (r.p.m.)	9,500	9,500	9,500	---
Spindle speeds for 44s (r.p.m.)	8,750	8,750	8,750	8,750
Spindle speed for 50s, 60s, 80s, & 100s (r.p.m.)	---	8,500	8,500	8,500
Roll settings (center to center):				
First to second, standard (inches)	2-1/16	2-1/16	2-1/16	2-1/16
Second to third, standard (inches)	1-3/4	1-3/4	1-3/4	1-3/4

1/ Based on Fibrograph upper half mean length as shown in table 2.
2/ Fiber lengths shown are in terms of "pulls" made on card sliver which are approximate equivalents of fibrograph upper half mean lengths used in laboratory procedure.
3/ See Item 9, Long draft spinning, for hanks delivered.

The spinning test reports include the following:

1. Grade and staple classification of the cotton.
2. Upper half mean length, mean length, and uniformity ratio as determined by the fibrograph.
3. Weight of cotton fed to the first picker.
4. Carding rate, picker and card waste percentage, and neps per 100 square inches of card web.
5. Comber setting and comber waste percentage when combed yarn tests are made.
6. Spinning twist multiplier, yarn skein strength of each yarn number, and average carded and/or combed yarn strength indexes.
7. Yarn appearance grade of each yarn number and average carded and/or combed yarn appearance indexes.
8. Comments summarizing any unusual processing observations that are not covered by the data reported.

In evaluating the spinning test results, too much significance should not be attached to small differences shown for individual tests. In practical application, it should be remembered that a small difference in a single measurable property may be overshadowed by other properties. Conclusions, therefore, should be made only after consideration of all test results.

The results of tests conducted on a large number of lots of cotton provide bases as described in subsequent paragraphs for the evaluation of specific test results.

Manufacturing waste.--The manufacturing waste for a sample of cotton is important because excessive waste increases the cost of processing. The percentage of waste extracted by the picking and carding processes in performing a spinning test provides a measure of manufacturing waste. There is an average relationship between this waste and grade which is an indication of the waste content of a cotton. As the quantity of waste extracted by the picker and card for a particular grade is affected by the characteristics of the fiber, the nature of the extraneous material, and whether the grade designation was lowered because of poor color, there are variations from the average relationship in the results for individual samples. Also, the rate at which the samples are carded affects the picker and card waste values because the more thorough carding action obtained when the carding rate is decreased extracts a larger quantity of waste. The longer staple cottons are generally carded at a lower rate than the shorter cottons in order to obtain acceptable yarn quality. Past experience has shown the average relationship between grade and manufacturing waste, as based on medium staple upland cottons when carded at 9-1/2 pounds per hour, to be

approximately as follows:

Grade	Average picker and card waste
	Percent
Good Middling	6.3
Strict Middling	7.2
Middling	8.1
Strict Low Middling	9.3
Low Middling	12.5
Strict Good Ordinary	15.6
Good Ordinary	18.3

When combed yarn tests are requested, the percentage of waste removed by the comber is furnished in addition to the picker and card waste. The shorter staple cottons are processed through the comber with a closer setting than that for the longer staple cottons because smaller comber waste percentages are usually extracted from this cotton in commercial practice.

Waste results obtained in the laboratories of the Cotton Branch for cottons which have been tested periodically over a period of years provide an indication of the reproducibility of results for this phase of the spinning tests, as follows:

Item	Standard error
Carded yarn tests (5 cottons in 2 laboratories):	
Picker and card waste (percent)	± 0.8

Nep content.--A desirable feature of any cotton is its relative freedom from neps, because they may be a source of trouble in manufacturing yarns and fabrics. The occurence of neps in appreciable numbers detracts from the appearance of those products. This is especially true when they are to be dyed or printed because neps absorb dyes differently and appear as spots on the material. A determination of the number of neps per 100 square inches of card web during the processing of each spinning test lot provides a measure of the nep content. This determination is based on 10 specimens of card web totaling 360 square inches and is evaluated independently by two technologists. When the nep count is high, the cotton is likely to produce rough and neppy yarns. The longer staple cottons are carded at a lower rate of production than the shorter staple cottons primarily because the longer staple cottons are more susceptible to the formation of neps. The following adjective descriptions based on standard weight card sliver of 40 grains per yard and the standard carding rate for the particular cotton will serve to classify cottons from the standpoint of neppiness:

Number of neps per 100 square inches of card web	
15 and below	Low
16 to 30	Average
31 to 45	High
46 and above	Very high

The nep results obtained in the laboratories of the Cotton Branch for cottons which have been tested periodically over a period of years provide an indication of the reproducibility of results for this phase of the spinning tests. The following value is based on 10 specimens per test for 3 medium staple upland cottons when carded at 9-1/2 pounds per hour in 2 laboratories:

Item	Standard error
Neps per 100 sq. in. of card web	± 2.9

Yarn strength and yarn strength index.--Probably the most important reliable single index of spinning quality is the yarn strength. An automatic reel, having a circumference of 1-1/2 yards, is used to form skeins for the test. Each of these skeins is composed of 120 yards of yarn obtained from a bobbin by 80 revolutions of the reel. After the skeins have been exposed for 4 hours or more to standard atmospheric conditions, they are broken on a pendulum-type tester similar to that shown in figure 12. A minimum of 25 skeins is tested to obtain the skein strength value reported for each yarn number in the test. In the yarn-testing laboratory, the actual breaking strength of each skein is recorded, along with the actual yarn number, which is obtained by weighing the broken skein on a yarn-numbering quadrant. These actual strength and yarn number data are used to calculate the breaking strength reported for each yarn number spun.

Yarn strengths of at least average are desirable, as they not only increase the range of usefulness of a given cotton but are also an indication of good spinning and weaving performance. In general, the strength values shown are higher than those obtained in commercial mills. This is explainable by the following facts: Twist multipliers used in spinning yarns at the laboratories are designed to give the highest yarn strengths obtainable from each individual cotton tested; that it is necessary to keep the laboratory processing machinery in excellent condition at all times in order to provide test results that are strictly comparable; and laboratory results are to a large extent based on yarns manufactured from pure varieties of cotton. In other words, the degree of precision which is necessary for laboratory testing may not be economically feasible in a commercial textile mill.

There is an average relationship between yarn strength and staple length, but this average varies, attributable to the characteristics of the fiber in individual samples. The yarn strength index as reported in connection with spinning tests provides a means of comparing yarn strengths obtained in the testing of a specific sample with those of the general average of cotton of the same staple length. When the yarn strength index shown for a given cotton is greater than 100, then that particular sample is above average with respect to yarn strength for its staple length. If, on the other hand, the yarn strength index is less than 100, then that particular sample is below average with respect to yarn strength for its

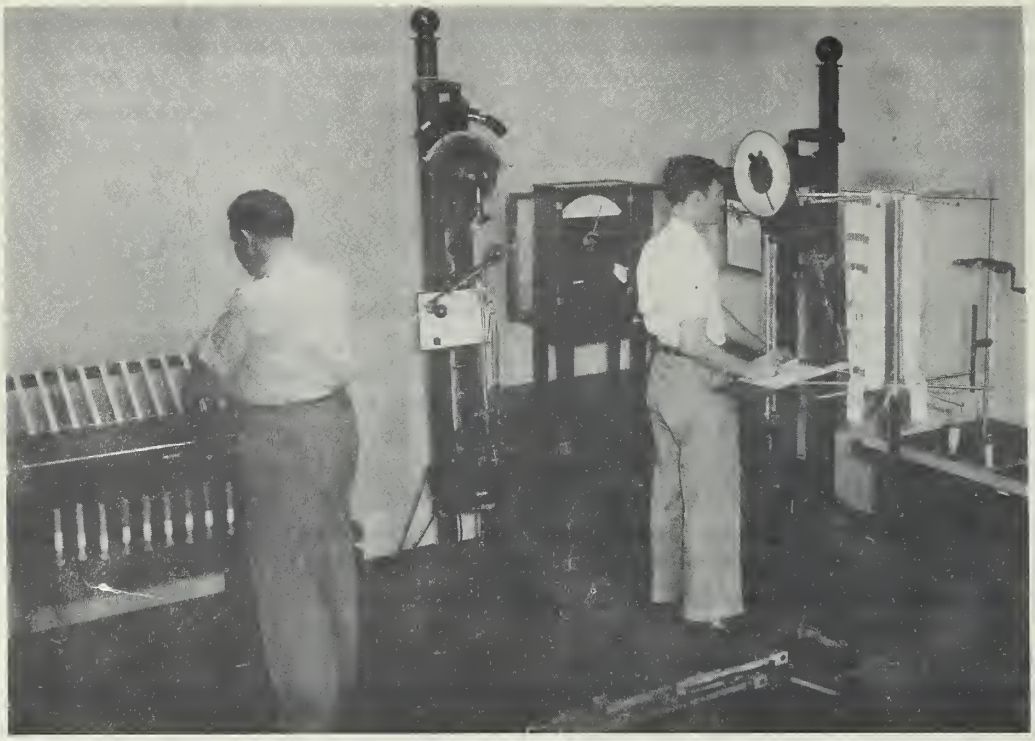


Figure 12.--Laboratory equipment used for determining yarn strength. Left to right: A reel for preparing skeins; single strand cord-tester, cabinet containing sizing quadrant for determing actual yarn number; pendulum-type tester; and a skein conditioning rack.

staple length. For example, a given test sample classed as 1 inch in staple length might have carded yarn strengths of 115 pounds for 22s and 40 pounds for 50s. In that case, the yarn strength index would be 103, indicating that the yarn strengths obtained were approximately 3 percent higher than the average of those obtained from cotton of 1-inch staple length.

The combing process contributes significantly to yarn strength, although this process is used primarily for the purpose of improving yarn appearance. Because of the higher range in yarn strength obtained from combed yarns, a different basis from that used for carded yarns is required for classfying them. Average yarn strengths for various staple lengths and yarn numbers are shown in table 4 for carded yarn and in table 5 for combed yarns. The values shown in table 4 and 5 are used as a basis for calculating the yarn strength indexes.

Yarn strength results obtained in the laboratories of the Cotton Branch for cottons which have been tested periodically over a number of

Table 4.--Average yarn strength for specified carded yarn numbers and staple lengths

Classer's staple length (inches)	Average yarn strength for carded yarn number --					
	14s	22s	36s	44s	50s	60s
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
3/4	133.5	78.3	40.8	-	-	-
25/32	140.1	82.5	43.3	-	-	-
13/16	146.6	86.6	45.8	-	-	-
27/32	153.1	90.8	48.4	-	-	-
7/8	159.7	95.0	50.9	38.4	-	-
29/32	166.2	99.1	53.5	40.4	-	-
15/16	172.7	103.3	56.0	42.5	-	-
31/32	179.3	107.4	58.6	44.6	-	-
1	185.8	111.6	61.1	46.7	38.9	-
1-1/32	192.4	115.8	63.6	48.7	40.7	-
1-1/16	198.9	119.9	66.2	50.8	42.5	-
1-3/32	205.4	124.1	68.7	52.9	44.4	-
1-1/8	212.0	128.2	71.3	55.0	46.2	35.4
1-5/32	218.5	132.4	73.8	57.1	48.0	37.0
1-3/16	225.0	136.6	76.3	59.1	49.8	38.5
1-7/32	231.6	140.7	78.9	61.2	51.7	40.0
1-1/4	238.1	144.9	81.4	63.3	53.5	41.6

Table 5.--Average yarn strength for specified combed yarn numbers and staple lengths

Classer's staple length (inches)	Average yarn strength for combed yarn number --						
	22s	36s	44s	50s	60s	80s	100s
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
1	122.8	67.2	51.3	42.8	32.3	-	-
1-1/32	127.3	70.0	53.6	44.8	34.0	-	-
1-1/16	131.9	72.8	55.9	46.8	35.6	-	-
1-3/32	136.5	75.6	58.2	48.8	37.3	-	-
1-1/8	141.1	78.4	60.5	50.8	39.0	24.2	-
1-5/32	145.6	81.2	62.8	52.8	40.7	25.5	-
1-3/16	150.2	84.0	65.1	54.8	42.3	26.7	-
1-7/32	154.8	86.8	67.3	56.8	44.0	28.0	-
1-1/4	159.4	89.6	69.6	58.9	45.7	29.3	19.4
1-9/32	163.9	92.4	71.9	60.9	47.4	30.5	20.4
1-5/16	168.5	95.2	74.2	62.9	49.1	31.8	21.4
1-11/32	173.1	98.0	76.5	64.9	50.7	33.0	22.4
1-3/8	177.7	100.8	78.8	66.9	52.4	34.3	23.4
1-7/16	186.8	106.3	83.4	70.9	55.8	36.8	25.4
1-1/2	196.0	111.9	87.9	75.0	59.1	39.3	27.4
1-9/16	205.1	117.5	92.5	79.0	62.5	41.8	29.4

years provide an indication of the reproducibility of results for this phase of the spinning tests, as follows:

Item	Standard error
Carded yarn strength (5 cottons in 2 laboratories):	
Coarse number (pounds)	± 2.5
Medium number (pounds)	± 1.6
Fine number (pounds)	± 1.2
Average index (percent)	± 1.8
Combed yarn strength (2 cottons in 1 laboratory):	
Coarse number (pounds)	± 2.0
Medium number (pounds)	± 1.8
Fine number (pounds)	± 1.2
Average index (percent)	± 1.6

Yarn appearance and yarn appearance index.--The appearance of the yarn in many types of woven or knitted materials is a very important quality factor. The appearance of each yarn number spun in connection with a spinning test is expressed in terms of yarn appearance grades. Photographic standards for these grades were developed by the laboratories of the Cotton Branch and have been adopted by the American Society for Testing Materials (figs. 13 and 14). The yarn appearance index provides a means of averaging the appearance grade of two or more yarn numbers and for comparing yarn appearance values obtained in the testing of a specific sample with those of the general average of cotton. A yarn appearance index greater than 100 indicates higher than average yarn appearance, whereas a yarn appearance index smaller than 100 indicates lower than average yarn appearance. For example, a given sample might have yarn appearance grades of B for 22s, and C+ for 50s. In that case, the yarn appearance index reported, which is based on all yarn numbers spun, would be 105, indicating that the yarn appearance grades obtained were above average. The following descriptive designations will aid in evaluating the results reported:

Yarn appearance

Grade	Designation	Index
A	Excellent	130
B+	Very good	120
B	Good	110
C+	Average	100
C	Fair	90
D+	Poor	80
D	Very poor	70
BG (Below grade).	Very poor	60

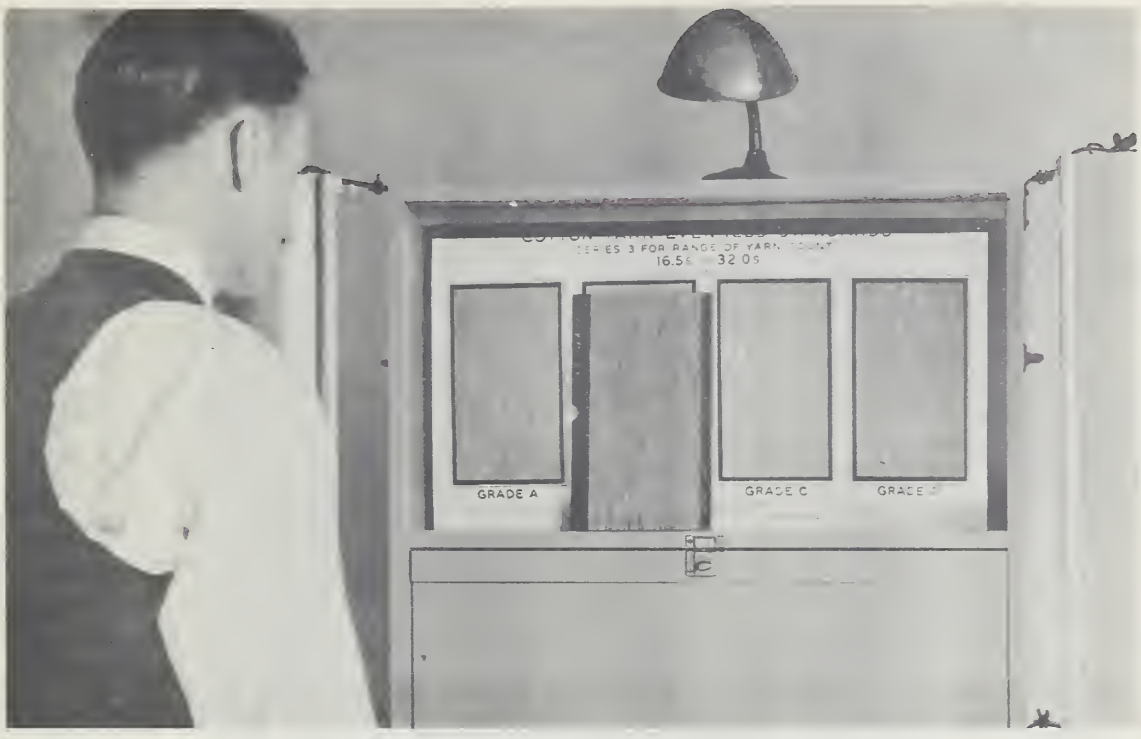


Figure 13.--Technician grading a yarn board against a cotton yarn appearance standard. The standards are fitted into a specially designed cabinet equipped with lamps and reflectors to facilitate accurate grading.

Yarn appearance results obtained in the laboratories of the Cotton Branch for cottons which have been tested periodically over a number of years provide an indication of the reproducibility of results for this phase of the spinning tests as follows:

Item	Standard error
Carded yarn appearance (5 cottons in 2 laboratories):	
Coarse number (index)	± 4.4
Medium number (index)	± 4.9
Fine number (index)	± 4.8
Average (index)	± 3.8
Combed yarn appearance (2 cottons in 1 laboratory):	
Coarse number (index)	± 6.6
Medium number (index)	± 5.2
Fine number (index)	± 5.2
Average (index)	± 4.5

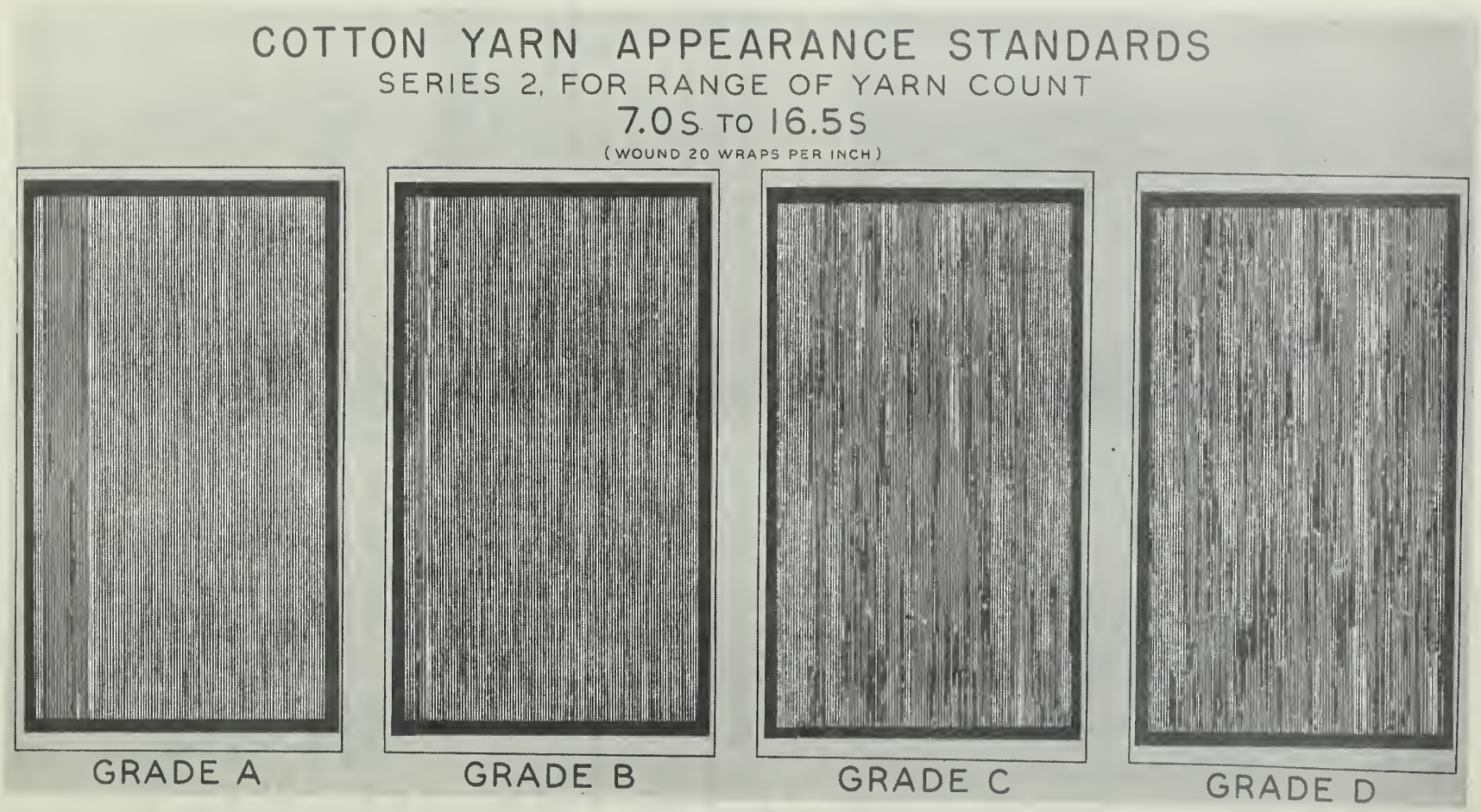


Figure 14.--One of the series of 5 standards used to grade yarns for appearance (about 1/3 actual size). Yarns wound on boards suitable for making visual examinations or for direct comparisons with the standards are sent to applicants as a part of each spinning test report.

Spinning twist test (16 and 17).--For test 16, one yarn number is spun with each of 6 twist multipliers from a sample of raw cotton, picker lap, sliver, or roving as a basis for determining the twist multiplier that will result in yarns having the greatest skein strength. The results obtained from the test also show the extent to which yarn strength falls off when somewhat more or less than the optimum twist is used. The test is made on any yarn, between 14s and 100s, that is within the spinnable range of the cotton, and the results are based on 25 skein breaks for each of the 6 twists spun. Spinning twist tests on additional yarn numbers or using additional twists from the same material can be obtained by requesting test item 17.

Furnishing yarn to applicant (18).--In those instances where a relatively small quantity of yarn is desired for futher study by the applicant, it may be obtained by requesting item 18. The yarn is wound on parallel paper tubes and charged for on a poundage basis. Yarn, either carded or combed, is supplied only in connection with spinning tests (items 11 through 14) and, when test 18 is requested, the sample of cotton submitted for the spinning test must be larger than the usual 5- or 8-pound sample, in proportion to the quantity of yarn needed.

Furnishing yarn appearance boards (19).--Yarn boards are prepared for the determination of the appearance grades of each yarn tested in connection with spinning or yarn tests (items 11 through 15, 20, and 23a). Item 19 provides a means for the applicant to obtain these boards when desired. The boards may be useful for grading in accordance with the cotton yarn appearance standards or for making other comparisons and inspections.

Spinning and testing additional yarn numbers (20).--In the event the two yarn numbers provided in connection with spinning tests are not adequate for the specific purposes of an applicant, provision is made for the spinning of any extra numbers desired so long as they are within the spinnable range of the cotton. Yarn skein strength and appearance grade are included in this test.

Plied yarn test (21 and 21a).--This test, which is made only in connection with spinning tests, includes the twisting and the testing of ply yarns. Test item 21 applies to 2- and 3-ply yarns and item 21a applies to 4 or more ply yarns that are not coarser than the equivalent of number 1 singles yarn. Yarn skein strength is reported for this test.

Cord test (22).--This test is offered only in conjunction with and as a supplement to a spinning test. The test affords a convenient medium for studying the results obtained for cottons manufactured into various plied and cabled constructions. Because of limitations in types of manufacturing and testing equipment at the laboratories, it is not feasible to make cords coarser than the equivalent of number 1 singles. Single strand yarn strength is reported for this test.

Waste and nep content (27).--This test affords a means for comparing the relative wastiness and neppiness of 5- or 50-pound samples of cotton in the event it is not desired to make complete spinning tests. The cotton is processed through the pickers and card for cleaning and waste removal in the same manner as for spinning tests. The percentage of picker and card waste and the average number of neps per 100 square inches of card web are reported for this item. These tests are discussed in preceding paragraphs under "Manufacturing waste" and "Nep content."

Fabric weaving and testing (30).--This test is offered as a supplement to spinning tests, and thus is only available with a spinning test. It includes the spinning of the additional yarn required, warping and slashing of yarn, and the weaving of a fabric 11-3/4 inches wide. Any standard fabric construction which the laboratories are equipped to produce may be specified by the applicant; otherwise, the fabric will be woven in accordance with the following nominal specifications:

Construction	68 x 72
Warp	21s
Filling	23.6s
Weight	4.9 oz. per yard

Results reported for this test show the actual and nominal weight of the fabrics, warp and filling counts, and the results of fabric strength warpwise and fillingwise in accordance with the methods outlined for item (29).

Other Tests

Yarn skein strength, number, and appearance grade (23 and 23a).--This test affords a means for a cotton manufacturer to compare yarns processed in his own mill from cottons submitted for laboratory spinning tests with yarns processed at the laboratories of the Cotton Branch. Item 23 includes the reeling, conditioning, breaking, and sizing of 25 skeins from the bobbins submitted as representative of a given lot of yarn. The average skein strength and average yarn number are reported. Item 23a includes the preparation and grading of one yarn appearance board. The average yarn appearance grade is reported.

Single strand yarn strength test (24, 24a, and 24b).--The Moscrop tester is a single strand strength-testing machine that accomodates 6 bobbins at one time. It automatically threads and breaks the yarn and records the strength automatically on a special recording chart from a minimum of 36 successive 10-inch lengths from each bobbin. The average breaking strength and the actual number of the yarn obtained by reeling and sizing one skein from each of the 6 bobbins are reported when item 24 is requested. Where detailed analyses of the individual breaks are desired, copies of the chart on which the breaks are automatically recorded will be furnished when item 24a is requested along with the Moscrop test.

The pendulum testing machine for single strand tests is similar to the one used for skein tests. It has a smaller capacity, however, and is equipped with single strand jaws. A total of 25 breaks is made on each lot of yarn tested and the average strength is reported for item 24b.

Furnishing identified cotton samples (26).--This item affords a means for the applicant to obtain identified samples taken at any of the stages of processing or testing for cottons submitted for fiber or spinning tests.

Determination of neps in card web (27a).--This test affords a means for a cotton manufacturer to compare the nep content of card web processed in his own mill from cottons submitted for laboratory spinning tests with the nep content of card web processed at the laboratories of the Cotton Branch. The test includes the evaluation of the nep content of specimens of card web furnished by the applicant on boards covered with black velvet and the reporting of the average number of neps per 100 square inches of card web.

Strength of fabric test, grab method (29).--This test affords a means for a cotton manufacturer to compare the fabrics processed in his own mill with fabrics processed in the laboratories of the Cotton Branch. The test includes the preparation of the samples and strength tests on five fabric specimens, measuring 4 by 6 inches each, for both warp and filling. The specimens are taken from fabric, furnished by the applicant, which should measure at least 1-yard square and should contain one selvage. The report includes the average strength for both warp and filling.

Furnishing extra copies of test data (31, 31a, and 32).--The test item for each type test includes two copies of the test report, but additional copies may be obtained by requesting item 31. A certified relisting of test results for selected samples from previous tests may also be obtained by requesting item 31a. Copies of the data work sheets which contain detailed data and calculations may be obtained by requesting item 32.

Variability within bales of cotton

In view of the high degree of variability for all measurable properties of cotton, the applicant for service tests should be fully aware of the limitations of the various tests that are imposed by such variability in the material tested. Otherwise, too much significance may be attached to small differences in the test results and erroneous conclusions may be drawn. It is for this reason that data pertaining to the variability of cotton within individual bales are included in this report.

Variability of cotton within a single bale actually is much greater than is usually appreciated. Fibers from bolls produced on different parts of a single cotton plant develop at different times under different environmental conditions. As a result, they vary considerably in physical

properties. Even on the same seed the fibers vary greatly, depending on their position on the seed. Frequently the cotton in a bale is harvested at different times and under different conditions. The cotton may come from different parts of the field and from different varieties. Under present procedures of ginning, a bale often contains some cotton from the bale ginned previous to it. There are other factors contributing to variability in cotton.

An indication of the extent of variability of the physical properties of cotton fibers within a single bale may be obtained from the data presented in table 6. Bales reported in this table were sampled in 10 positions throughout each bale and the test results were based on tests made on the individual samples. It should be understood, however, that these data represent about the minimum of variability for commercial bales of cotton because each bale reported in table 6 consisted of cotton of a pure variety that was so ginned and selected as to provide maximum practical uniformity in quality within the bale in each instance. Most bales of cotton will show greater variability than that indicated here in table 6

Relationship of Test Data to Published Reports

Users of the testing service may, upon request, have their names placed on a mailing list to receive publications, issued from time to time, dealing with various research studies and reporting test results for the improved varieties of cotton grown and tested each year. The data reported in these publications provide a basis for evaluating test results and for comparing the specific cottons submitted for test with the various improved varieties. In making such comparisons, however, it should be kept in mind that the precision indicated in this report will, no doubt, be further improved. The test methods are being studied continually for the purpose of improving the precision of the tests and reducing the time required for performing them.

Table 6.--Extent of variability in specified fiber properties within individual bales of pure variety cotton, selected to assure maximum practical uniformity in quality, in comparison with standard errors of fiber tests

Bale No.	Range of fiber measurements within bales 1/				
	Length - Fibrograph		Strength (Pressley)	Fineness (Micronaire)	Maturity (Random Sample)
	Upper half mean	Uniformity			
	Inches	Index	1,000 lb./ per sq. in.	ug/in.	Percent
1	0.03	3	9	0.2	7
2	.04	2	6	.2	7
3	.02	1	6	.2	8
4	.02	5	7	.2	10
5	.04	4	4	.1	8
6	.03	5	5	.1	12
7	.06	2	4	.3	13
8	.02	3	4	.2	8
9	.03	3	5	.2	11
10	.04	2	9	.3	13
11	.07	3	5	.2	6
Average	.036	3.0	5.0	0.20	9.4
Standard error for test 2/	± 0.008	± 1.1	± .9	± .05	± 1.0

1/ Data with respect to variability within bales are based on 10 complete tests made on 10 samples taken from different positions throughout each bale.

2/ Data with respect to precision of tests are based on special studies.